D R A F T   T E C H N I C A L   M E M O R A N D U M

TERRESTRIAL ECOLOGICAL RISK ASSESSMENT APPROACH FOR MIDNITE MINE RI/FS

Prepared for

U.S. Environmental Protection Agency
Region 10

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1.0 INTRODUCTION

This document describes the approach for the Midnite Mine Terrestrial Ecological Risk Assessment (TERA). The TERA will assess the potential risk to terrestrial organisms from Midnite Mine site-related contaminants in surface materials, sediments, and surface water. (For the TERA, the term "surface materials" will include surface and subsurface soil samples collected at the Midnite Mine Site.)

The overall ERA process is summarized in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997):

> . . . an integral part of the Remedial Investigation and Feasibility Study (RI/FS) process, which is designed to support risk management decision-making for Superfund sites. The RI component of the process characterizes the nature and extent of contamination at a hazardous waste site and estimates risks to human health and the environment posed by contaminants at the site. The FS component of the process develops and evaluates remedial options . . .

According to USEPA (1997), an ERA functions to:

(1) Document whether actual or potential ecological risks exist at a site;
(2) Identify which contaminants present at a site pose an ecological risk; and
(3) Generate data to be used in evaluating cleanup options.

The objective of the Midnite Mine TERA is to document whether actual or potential risk to terrestrial biota or habitats exists at the Site, and to identify contaminants of concern (COC) that pose the risk in different areas of the Site. This information will be considered in the development and evaluation of remedial alternatives for the Site.

The TERA will be performed in accordance with U.S. Environmental Protection Agency's (USEPA's) most recent risk assessment guidance: *Guidelines for Ecological Risk Assessment* (USEPA 1998) and *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997). The TERA approach also incorporates elements of *Framework for Ecological Risk Assessment* (USEPA 1992) and *ECO Update – The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA 2001).

The TERA will include the three standard elements of an ERA, as described in USEPA guidance (1992, 1998): Problem Formulation (Section 2 of the TERA), Risk Analysis (Section 3), and Risk Characterization (Section 4). This technical memorandum describes how these elements will be applied in the TERA and lists references used in developing the approach.

USEPA issued a draft Aquatic Ecological Risk Screening (ERS) (URS 2001b) using sediment and surface water data from Fall 1999 and Spring 2000 field work. Because surface material samples were collected in Fall 2000 and 2001, data for terrestrial risk screening were not available at the time. USEPA decided to omit the screening stage of the terrestrial risk assessment process and to solicit input from stakeholders on the proposed approach for terrestrial ecological risk assessment. Ultimately, the Baseline ERA will integrate both the TERA using the approach described in this document and the aquatic risk assessment.

USEPA will review information developed during the risk assessment and will make management decisions after considering input from the stakeholders. Stakeholders for Midnite Mine include the Spokane Tribe of Indians, US Fish and Wildlife Service (USFWS), and others.

2.0 PROBLEM FORMULATION

The problem formulation component of the TERA will contain four principal sections: (1) characterization of the terrestrial ecosystem, (2) assessment and measurement endpoints, (3) conceptual site model (CSM), and (4) identification of contaminants of potential concern (COPCs).

2.1 Characterization of the Terrestrial Ecosystem

A characterization of ecological habitats and biota of the Midnite Mine Site was presented in the Technical Memorandum, *Ecological Characterization of Midnite Mine* (URS 2000a). Midnite Mine is located in northeast Washington, approximately eight miles northwest of the town of Wellpinit, Stevens County (Figure 2-1). The four primary habitat types identified on the Midnite Mine Site include: upland habitat, riparian and wetland habitat, riverine habitat, and lacustrine habitat. The TERA evaluates potential risk to habitats and terrestrial organisms in the upland, riparian, and wetland habitat types.

The upland habitat and riparian and wetland habitat features in the vicinity of the Midnite Mine Site are shown in Figures 2-2 and 2-3. Upland habitat occurs outside the zone of immediate influence of surface water bodies (e.g., creeks, ponds, seeps) and/or ground water. A variety of sub-habitat types occur in the uplands including forested, grassland, open, and steep sub-habitats. Extensive upland habitat is found within the Mined Area (MA), Potentially Impacted Area (PIA), and Blue Creek corridor. The quality of the upland habitat has been physically degraded within the MA. Upland habitat outside the MA is largely undisturbed from mining activities throughout most of the PIA and Blue Creek corridor. Riparian ecosystems are riverine floodplains and streambank ecosystems (Stinson and Gilbert 1985). The riparian zone encompasses the stream channel between the low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Decamps 1997). Wetlands occur within the zone of influence of surface water bodies (e.g., creeks, ponds, seeps) and/or groundwater and are typified by plant species associated with saturated soil conditions during the growing season (e.g., cattails, sedges, rushes). The riparian and wetland habitats within the Midnite Mine project area are of limited extent occurring either as a narrow band on the banks of streams or as small isolated areas associated with seeps within the MA and Blue Creek corridor. For the purposes of the ecological characterization and TERA, the riparian and wetland habitats are grouped together. Although the riparian and wetland habitats are of limited spatial extent within the project area, they have considerable ecological and social value.

For the purposes of the TERA, the PIA consists of upland, riparian, and wetland environments within approximately ¼ mile (1,320 ft) of areas potentially affected by mining activities (Figure 2-2). The PIA includes the Midnite Mine drainage basin and the Blue Creek watershed downstream of the MA. The PIA contains the Eastern, Central, and Western Drainages as well as the East Haul Road area, which is located immediately east of the Midnite Mine drainage basin. The portion of the Blue Creek watershed in the PIA begins immediately above the Northern Drainage confluence with Blue Creek and continues downstream to the confluence with the Spokane Arm of Franklin D. Roosevelt Lake.

Ecological habitats and biota of the Midnite Mine Site were characterized in the Technical Memorandum, *Ecological Characterization of Midnite Mine* (URS 2000a).

2.2 Assessment Endpoints and Measures

Ecological endpoints to be considered in the TERA are generally characterized as assessment endpoints and measures of effect, exposure, and ecosystem and receptor characteristics (USEPA 1989; 1992; 1998). Assessment endpoints are formal expressions of the environmental values that are to be protected, and measurement endpoints were defined as measurable environmental characteristics that are related to the valued characteristics that are to be protected (Suter 1993). However, the USEPA (1998) replaced the term "measurement endpoints," which addressed the response of an assessment endpoint to a stressor, with more inclusive "measures." The three categories of measures as defined in USEPA (1998) include:

- Measures of effect - measurable changes in an attribute of an assessment endpoint or its surrogate in response to a stressor (e.g., a chemical) to which it is exposed (formerly "measurement endpoints")
- Measures of exposure - measures of stressor existence and movement in the environment and their contact or concurrence with the assessment endpoint
- Measures of ecosystem and receptor characteristics - measures of ecosystem characteristics that influence the behavior and location of entities selected as assessment endpoints, the distribution of a stressor, and life-history characteristics of the assessment endpoints or their surrogates that may affect exposure or response to the stressor

Measures of effect are addressed quantitatively in the Risk Estimation (Section 4.1). Measures of exposure are addressed in the Exposure Analysis (Section 3.1), and measures of ecosystem and receptor characteristics are qualitatively addressed in several sections, including Risk Description (Section 4.2).

Assessment endpoints are identified based on the following three considerations (USEPA 1992):

- Ecological relevance (structure and function of the ecosystem)
- Policy goals and societal values (endangered, threatened, or species of special concern)
- Susceptibility to the COPCs (i.e., chemical stressors)

At the Midnite Mine Site, the primary assessment endpoint can be stated as "protection of the health and sustainability of the terrestrial and aquatic ecosystems at the Midnite Mine Site" (URS

2000a). Beginning with this primary endpoint, the assessment endpoints to be used in the TERA are:

- Protection of the upland and riparian plant communities
- Protection of soil organism communities
- Protection of threatened and endangered wildlife species
- Protection of wildlife (functional groups) populations

All wildlife functional groups (i.e., receptors) are considered ecologically relevant and their interactions are essential for maintaining ecological integrity. Food web exposure pathways to the functional groups and other relevant factors were considered in selection of the assessment endpoints. Functional groups present on the Midnite Mine Site are listed and characterized below:

<u>Primary and Secondary Consumers - Terrestrial Insectivores/Invertivores (Small Birds, Small Mammals, and Amphibians)</u>

- direct exposure to contaminated surface materials as well as exposure through ingestion of invertebrates
- small home range (exposure area)
- toxicity data available

<u>Primary Consumers - Herbivores (Birds and Mammals)</u>

- direct exposure to contaminated surface materials as well as exposure through ingestion of plants
- small to medium home range size
- important intermediate food sources
- toxicity data available
- low on food chain (prey for higher-level carnivores)

<u>Tertiary and Quaternary Consumers - Carnivores (Birds and Mammals)</u>

- upper trophic level (greatest potential to be affected by biomagnification of contaminants)
- large foraging range
- differential sensitivity (bird and mammal)
- ecologically important as “top down” control in terrestrial ecosystems

The selection of protection of these wildlife functional groups as assessment endpoints and identification of receptor groups for this risk evaluation was based on five characteristics or data sets. The five items are: (1) known or presumed presence at the Site; (2) presence of a complete exposure pathway; (3) nature of the contaminants (i.e., can the contaminant, either directly or indirectly, measurably affect organisms within a designated functional group); (4) susceptibility to bioaccumulation or biomagnification effects; and (5) availability of toxicity data. Receptors that will be included in the TERA (Table 3-1) were identified by stakeholders during a Biological Technical Assistance Group (BTAG) meeting in September 2000 and a series of phone conferences with stakeholders held subsequently through November 2000.

Measures for evaluating effects of each chemical stressor on the receptors will be based primarily on Lowest Observed Adverse Effect Level (LOAEL) and No Observed Adverse Effect Level (NOAEL) (for threatened and endangered species) toxicity benchmarks developed from laboratory studies. LOAEL benchmarks are based on the dose or concentration of a chemical where adverse effects are first noted in laboratory studies (Sample et al 1996). LOAELs represent threshold levels at which adverse effects may become evident in the field. Efroymson et al. (1997a) observed that LOAELs based on effects to individual test organisms are expected to represent negligible-effects risk levels for wildlife populations. NOAEL-based benchmarks represent values believed to be nonhazardous for wildlife species. Wildlife benchmarks are derived from toxicological data for a limited variety of standard laboratory test organisms (e.g., rat, mouse, duck, chicken). Laboratory toxicity benchmarks are commonly used as surrogate measures of potential adverse effects from a chemical requiring extrapolation of laboratory test organism data to specific receptors likely to occur onsite, but whose relative sensitivities to chemical stressors under site conditions are not well known.

Ecological effects of most concern are those that can impact populations or higher levels of ecological organization. Toxicological effects most likely to affect populations are those that affect individual growth, reproduction, and survival. LOAELs and NOAELs for these types of chronic toxic effects will be used in the TERA to evaluate the potential for adverse effects to terrestrial receptors at a given location. Because the receptors in this evaluation are functional ecological groups rather than individual species, exceedance of a benchmark value for a particular medium (surface material, water) presumes that any member of that functional group could be potentially exposed and adversely affected. However, as mentioned previously, LOAELs based on effects to individual test organisms are expected to represent negligible-effects risk levels for wildlife populations (Efroymson et al., 1997a).

In addition to the wildlife functional groups, the producers (vascular plants) also will be evaluated in the TERA. Unlike wildlife receptors, producers will be evaluated with concentration-based, not dose-based, comparisons. Following is a brief description of producer characteristics:

<u>Producers - Vascular Plants</u>

- provide habitat for wildlife
- plant groups sensitive to phytotoxic contaminants
- direct contact with contaminated surface materials

- widespread and ecologically important (i.e., food, habitat, energy and nutrient fixation)
- represent local impacts in a contaminated area

2.3 Conceptual Site Models

Movement of chemicals through a biotic food chain follows the same basic principles and pathways for any plant and animal community. Figure 2-4 shows a generalized food web for the Site. The food web illustrates the movement of food/nutrition/energy from the decomposing organic material (detritus) through plants, herbivores, and predators. As plants and animals die, their remains ultimately return to the base of the food web (not illustrated). The food web forms the basis for the CSMs that show potential exposure pathways from abiotic media (e.g., sediment) through the various trophic levels of the terrestrial/riparian ecosystem. Over 150 wildlife species (mammals, birds, reptiles and amphibians) may potentially occur at the Midnite Mine Site (URS 2000a). These species were categorized into functional groups for use as wildlife receptors in the CSM and the risk model.

Based on an understanding of the food web for the Site (Figure 2-4), a total of six CSMs (Figures 2-5 through 2-10) have been developed for various areas of the Site. (A similar set of CSMs has been developed for use in the human health risk assessment.) The CSMs are based on existing Site data, selected assessment endpoints, appropriate measures, and terrestrial receptor organisms. While similar in general appearance to food webs that illustrate the movement of energy, CSMs trace the movement of chemical contamination from various sources through abiotic (i.e., non-living) media to the biotic components of the system, the eventual ecological organisms that may be adversely affected by the COPCs. CSMs illustrate the potential exposure of ecological receptors but are not meant to illustrate ecological risk since risk incorporates both exposure and toxicity of contaminants to the receptors.

The following will aid in interpretation of the exposure pathway information in each CSM:

- The highlighted boxes apply to the terrestrial system being evaluated.
- The term “Ingestion” includes direct (incidental) ingestion of surface material, sediment, or water. Ingestion also includes consumption of food items that have accumulated COPCs from the abiotic exposure media.
- “Direct Contact/Uptake” applies most directly to plants, soil biota, and amphipods that are evaluated on the basis of concentrations in the exposure media. Other receptors may have direct contact, but any evaluation will be qualitative only, as indicated by an open circle.
- Filled-in circles denote that exposure is assumed to be complete, and a quantitative evaluation of the exposure and potential risk to the receptor and exposure route will be performed if appropriate for the exposure area being considered.
- Open circles denote that exposure may be complete, but a qualitative assessment only will be performed if the receptor is exposed in the exposure area being considered.
- Dashes denote that the exposure pathway is incomplete and no assessment will be performed.

2.4 Identification of Contaminants of Potential Concern

Site-related stressors to the terrestrial ecosystem at the Midnite Mine Site include both inorganics (i.e., metals) and radionuclides in surface material, sediment, and surface water.

Identification of COPCs considered in the TERA will be based on a series of four criteria. All four criteria must be satisfied for a contaminant to be considered a COPC:

- **Detected in exposure medium (surface material, sediment, or surface water)**. All inorganics and radionuclides that were detected in surface material, sediment, and surface water as part of Site investigations by Ecology & Environment during 1998 (E&E 1998); by Shepherd-Miller, Inc. in 1999 (SMI 1999); or by URS during the Phase 1A, Rounds 1 and 2 (1999 and 2000) and Phase 2B (Summer 2001) will be listed in the final ERA document.
- **Considered to be a pollutant or contaminant under the National Contingency Plan (40 CFR Part 300.5) plus other site-related, potentially toxic pollutants.** All site-related inorganics and radionuclides detected in surface material, sediment, and surface water and considered contaminants (i.e., reasonably expected to cause death, disease, or physiological malfunctions) will be retained for further evaluation.
- **Concentration greater than background.** The chemical and radionuclide concentrations measured in surface material, sediment (composite and grab samples), and surface water must exceed their respective background limits to be retained as preliminary COCs. Complete details of the background statistics and identification of mine-affected sub-areas will be based on the methods provided in the technical memorandum *Statistical Approach For Discrimination of Background and Impacted Areas for Midnite Mine RI/FS* (URS 2001a).
- **Detected in at least 5 percent of samples from an exposure area.** For each exposure area (i.e., mine-affected sub-area) evaluated in the TERA, all metals and radionuclides detected in at least 5 percent of each group of samples collected (minimum of 20 samples required) will be retained as per USEPA (1989). Groups of samples for each exposure area include: samples of surface material, composite and grab samples of sediment, dissolved metals and total metals in surface water, and radionuclides in the combinations of surface material and surface water, composite sediments plus surface water, and grab sediments plus surface water.

3.0 ANALYSIS

The analysis component of the TERA will contain two principal sections: Exposure Analysis (Section 3.1) and Ecological Effects of Chemicals (including radionuclides) (Section 3.2).

3.1 Exposure Analysis

In the exposure analysis, surface material, sediment, and surface water chemical data collected from the Midnite Mine Site will be compiled for use in characterizing exposure of terrestrial receptors to chemical stressors. Exposure concentrations described in this section and toxicity benchmark concentrations described in Section 3.2 will be compared to determine the risk estimation as shown in Section 4.1. In compiling the site-specific data, the following factors will be considered in order to develop an understanding of the likely magnitude and duration of terrestrial receptor exposure:

- Uptake from surface material and sediment by upland and riparian vegetation
- Direct contact with surface material by soil organisms
- Direct ingestion and food-chain exposure from surface materials for birds and mammals
- Direct contact/ingestion and food-chain exposure from surface water by fish-eating birds and mammals (piscivores)
- Spatial variability in chemical concentrations
- Use of Site habitats (area and duration) by receptors

Surface material, sediment, and surface water quality data collected from uplands, streams, pits, and lagoons on the Midnite Mine Site during Spring 1998 through Summer 2001 form the basis for the Terrestrial ERA. Data from reports by Ecology and Environment (E&E 1998), Shepherd Miller, Inc. (SMI 1999), and URS (2000b) have been compiled into an electronic database. Data from the April 2000 (URS Phase 1A, Round 2) and August 2001 (Phase 2B) sampling will be compiled directly into the database. Segregation of this data for use in the TERA is described in Section 3.1.1.

The exposure analysis will be performed using the functional receptor groups described in Section 2.2 and the site-specific data for surface material, sediment, and surface water. For inorganics in surface material, exposure concentrations will be calculated for each exposure sub-area (described in Section 3.1.1). The methods used for calculating the exposure concentrations are dependent on the underlying statistical distribution of the data (i.e., are the data distributed normally or log normally, or is the distribution unknown?). The exposure concentration will be the lower of the 95% upper confidence limit of the mean (UCL) or the maximum detected concentration. The maximum detected value will represent the exposure concentration for exposure sub-areas where there are fewer than three sample results because calculation of variance (and 95% UCL) for two or fewer values is mathematically trivial. For the purpose of exposure in the TERA, the surface material exposure concentration will be the higher of the calculated exposure concentrations for either surface or subsurface soils.

Representative species of the functional receptor groups (i.e., receptors) and their exposure pathways are listed in Table 3-1. Exposure analysis for terrestrial receptors are described in Sections 3.1.2 through 3.1.4.

3.1.1 Exposure Areas

An exposure area is the location where exposure is presumed to occur during exposure of the receptors. Preliminary exposure areas for the MA and PIA are described in this section. Exposure areas will be defined based on the nature and extent of contamination. Mine-affected sub-areas (within each preliminary exposure area) in the PIA and MA will be delineated using methods described in the *Statistical Approach For Discrimination of Background and Impacted Areas for Midnite Mine RI/FS* (URS 2001a). Only these mine-affected sub-areas will be evaluated in the TERA.

Upland PIA Surface Materials

For upland PIA surface materials, the areas to the northeast and southwest of the MA are considered to have the greatest potential for being affected by windborn contaminants from the MA because these areas are in the two principal downwind areas from the MA. If found to be affected by mining as described in URS (2001a), data from the affected sub-areas will be included as the Upland PIA exposure area.

Haul Road Margin Surface Materials

Wildlife may use haul roads as migration paths and may use haul road margins (sides) for feeding. Surface materials along haul road margins that are found to be affected above background (URS 2001a) will be included as a TERA exposure area.

MA Surface Material and Pit and Seep Sediment and Surface Water

Terrestrial receptors could potentially forage in the MA and seeps as well as drink water from pits and seeps. If the sampled media in the MA are found to be affected above background, this area will be included in the TERA as an exposure area.

Riparian Areas

For mine-affected riparian areas, sediments and surface water samples will be segregated into similar exposure areas considered in the *Draft Aquatic Screening for Midnite Mine RI/FS* (URS 2001b). The riparian exposure areas will include mine-affected sub-areas within the following stream segments and water bodies:

- Surface water in Upper Eastern Drainage (above Central Drainage), Lower Eastern Drainage (below Central Drainage), Central Drainage, Upper Blue Creek (above Eastern Drainage), Middle Blue Creek (between Eastern Drainage and Oyachen Creek), Lower Blue Creek (below Oyachen Creek), Franklin D. Roosevelt Lake, Pit

3, Pit 4, Pollution Control Pond (PCP), Western Drainage, Northeastern Drainage, Far Western Drainage, Outfall Pond, and Blood Pool (Figure 2-2).

- Sediment in the areas listed above plus sediment in the Northern Drainage and Southwestern Drainage.

3.1.2 Exposure Analysis for Plants, Soil Organisms, and Earthworms

In the exposure analysis, surface material chemical data (i.e., higher of the surface or subsurface soils) collected from mine-affected sub-areas will be compiled for use in characterizing exposure of plants, soil organisms, and earthworms to chemical stressors. Evaluation of potential risk for terrestrial plants, soil organisms, and earthworms will be evaluated by directly comparing exposure concentrations in surface materials to soil concentration-based benchmarks described in Section 3.2.1.1

3.1.3 Exposure Analysis for Amphibians

In the exposure analysis for amphibians, surface water chemical data within the affected sub-areas (i.e., exposure areas) will be compiled for use in characterizing exposure of amphibians to chemical stressors. Evaluation of potential risk for amphibians will be evaluated by directly comparing surface water exposure concentrations in each stream segment/water body to surface water concentration-based benchmarks described in Section 3.2.1.2.

3.1.4 Exposure Analysis for Birds and Mammals

In the exposure analysis for birds and mammals, surface material (i.e., higher of the surface or subsurface soils), sediment, and surface water chemical data collected from the Midnite Mine Site will be compiled for use in characterizing exposure of birds and mammals to chemical stressors. Evaluation of potential risk for birds and mammals will be evaluated by comparing media-specific concentrations to risk-based concentrations (RBCs) described in Section 3.2.1.3 to assess potential risk as described in Section 4.2.

3.2 Ecological Effects of Chemicals

3.2.1 Inorganics

Toxic effects and mediating factors for those inorganics that are retained for risk evaluation (i.e., COPCs) will be provided in the TERA. Factors such as uptake and bioavailability as well as toxicity to plants and wildlife will be discussed. This information will be used to facilitate interpretation of the risk estimates.

Exposure concentrations described in Section 3.1 and the ecological effects of chemicals described in this section as toxicity benchmark concentrations will be compared to determine the risk estimation as shown in Section 4.1.

3.2.1.1 Ecological Effects of Chemicals for Plants, Soil Organisms, and Earthworms

Evaluation of potential risk for terrestrial plants, soil organisms, and earthworms will be evaluated by directly comparing surface material exposure concentrations to soil concentration-based benchmarks. Terrestrial screening benchmarks for plants, soil microorganisms, and earthworms will be the benchmarks published by Oak Ridge National Laboratory (ORNL) (Efroymson et al. 1997a,b). No additional uncertainty factors will be applied to these ORNL screening benchmarks (see Table 3-2).

3.2.1.2 Ecological Effects of Chemicals for Amphibians

Evaluation of potential risk for amphibians will be evaluated by directly comparing surface water exposure concentrations to surface water concentration-based benchmarks. USEPA has not developed water quality criteria specifically for amphibians. Therefore, toxicity reference values (TRVs) from *Amphibian Toxicity Data for Water Quality Criteria Chemicals* by USEPA (Schuytema and Nebeker 1996) will be used to derive screening benchmarks for calculating risk to amphibian wildlife. The amphibian benchmarks used in the TERA will be the benchmarks published in Schuytema and Nebeker (1996). The TRVs for amphibians and the literature sources for each are shown in Table 3-3. Uncertainty factors have been developed to calculate final chronic LOAEL and NOAEL benchmarks where LOAELs and NOAELs were unavailable from literature. The uncertainty factors used will be based on the ratio of reported chronic and acute toxicity data for amphibians for cadmium and dieldrin as reported in Schuytema and Nebeker (1996). Final chronic LOAELs will be based on acute median lethal concentrations (LC_{50}s) and will be divided by an uncertainty factor of 20, except for boron and cadmium. For boron, the final chronic LOAEL is based on the threshold lethal concentration (LC_1) multiplied by an uncertainty factor of 20. For cadmium, the final chronic LOAEL is directly from Schuytema and Nebeker (1996). Final chronic NOAEL values will be based on acute LC_{50} values divided by an uncertainty factor of 40, except boron and cadmium. For boron, the final chronic NOAEL will be directly from Schuytema and Nebeker (1996) (reported as LC_1). For cadmium, the final chronic NOAEL will be directly from Schuytema and Nebeker (1996).

3.2.1.3 Ecological Effects of Chemicals for Birds and Mammals

Potential risk for birds and mammals will be evaluated by comparing surface material, sediment, and surface water concentrations (Section 3.1.3) to risk-based concentrations (RBCs) developed as described below to assess potential risk as described in Section 4.1.

RBCs will be developed based on literature toxicity benchmarks and receptor-based exposure media concentrations. RBCs for mammalian and avian receptors will be calculated by setting the hazard quotient (HQ) at one (1.0) and back-calculating LOAEL- and NOAEL-based (for threatened and endangered species) concentrations for each receptor, COPC, and abiotic exposure medium (described below).

Hazard Quotient

The HQ is the ratio of the exposure dose to a toxicity benchmark considered to represent a "safe" dose that will not result in an ecologically significant adverse effect:

$$\text{Hazard Quotient} = \frac{\text{Exposure Dose}}{\text{Toxicity Benchmark}}$$

For birds and mammals, the numerator of the HQ algorithm is based on an estimate of chemical doses (mg of chemical/per kg-body weight/per day) as follows:

Exposure Dose (mg/kg-bw/day) = (EDI x BA x F)/(BW)

and EDI = $(C_f \times I_f) + (C_s \times I_s) + (C_w \times I_w)$

where:

EDI = estimated daily intake of the potential COC expressed as mg/day or L/day

C_f = COPC exposure concentration in food; expressed as mg/kg

I_f = ingestion rate of food; expressed as kg/day

C_s = COPC exposure concentration in surface material or sediment; expressed as mg/kg or mg/L

I_s = incidental surface material or sediment ingestion rate; expressed as kg/day

C_w = COPC exposure concentration in drinking water; expressed as mg/L

I_w = ingestion rate of drinking water; expressed as L/day

BA = bioavailability of the COPC expressed as a percentage. Bioavailability is assumed to be 100 percent (equal to 1). Actual bioavailability for mining-related chemicals is probably less than 100 percent, as documented in the scientific literature (USEPA, 1999; 2001).

F = receptor- and site-specific area use factor; this accounts for the proportion of the receptor's time spent potentially exposed to chemicals at a particular site or subunit and considers home range, foraging behavior, migratory patterns, and the size of potentially contaminated habitat available; for each receptor and subsite combination, F can have a value equal to or less than 1.0.

BW = body weight of the receptor; expressed as kg.

Risk Based Concentration

By setting the HQ at 1.0, the dose is equivalent to the toxicity benchmark:

$$1.0 = \frac{\text{Exposure Dose}}{\text{Toxicity Benchmark}}$$

Therefore: Exposure Dose = Toxicity Benchmark

The equation will be solved for COPC concentrations in surface material, sediment, and surface water. First, C_w will be set at zero and the equation is solved for C_s; then the C_s will be set at zero and the equation is solved for C_w. RBCs are more readily comparable to Site concentrations than forward-calculated HQs because they are calculated only one time for each receptor and COPC and are expressed as concentrations (mg/kg COPC in surface material, mg/L COPC in water). RBC comparisons are also more intuitively obvious than comparisons of exposure doses to toxicity benchmarks (mg/kg-bw/day).

The chemical concentration in the tissue of food items eaten by wildlife receptors will be calculated using the following equation:

$$C_f = BAF \times C_s$$

where:

BAF = chemical-specific bioaccumulation factor

C_s = COPC exposure concentration in surface material or sediment; expressed as mg/kg or mg/L

Where applicable, site-specific uptake values for upland (aboveground and roots separately), riparian (aboveground and roots separately), and aquatic plants site-specific plant tissue data and/or site-specific uptake factors for Site vegetation will be taken into consideration. Site-specific uptake factors for plants are provided in Appendix A of the *Draft Human Health Risk Assessment Work Plan for the Midnite Uranium Mine* (URS 2001c) which has been submitted for USEPA review. For chemicals without site-specific uptake values, plant uptake values from Table 3-4 will be used. The ORNL regression equations for plant uptake from soil are not specific to particular plant species or parts of the plants (roots versus shoots), nor are they necessarily appropriate for the naturally mineralized soils at this Site (Bechtel Jacobs Co. 1998a). The ORNL median (default) uptake values were considered acceptable as far as providing a conservative risk estimate. Uptake factors from sediment to aquatic plants are virtually the same as uptake factors from soil to terrestrial plants, according to evidence reported by Folsom et al. (1988); therefore, the same soil to plant uptake factors will be used for sediment to aquatic plants in the TERA.

Chemical parameters and uptake (BAF, bioconcentration) factors for the analytes to be evaluated in the TERA are shown in Table 3-4. Sources for uptake factors from water, soil, and fish to biota also are referenced on Table 3-4. USEPA's ambient water quality criteria documents were the principal source of the aquatic bioconcentration factors. Publications from ORNL were the principal sources of uptake factors from sediment and soil to invertebrates (Bechtel Jacobs Co. 1998a,b; Sample et al. 1998a,b). Research Triangle Institute (1995) was another source for uptake factors where no ORNL values were available.

<u>Wildlife Exposure Factors for Birds and Mammals</u>

Wildlife exposure factors for body weight, food ingestion rate, incidental soil ingestion rate, water intake rate, and dietary composition for each representative wildlife receptor are shown in Table 3-5. USEPA's (1993) Wildlife Exposure Handbook is the principal data source for these wildlife exposure factors. In cases where species-specific information is lacking or difficult to develop, conservative assumptions will be used and documented.

The wildlife exposure factors to be used in the TERA (i.e., body weight, food, water, and soil ingestion rates) will employ the USEPA (1993) and Sample et al. (1996) values for representative wildlife species. Each species is considered to be a representative of the general diet composition, food and water intake rates, and body weight for that functional receptor group. The functional groups do not have firm dietary boundaries, as individual species can be in two or more categories (e.g., omnivore, herbivore, carnivore), depending on the species' diets that vary yearly and seasonally. Use of representative species and their exposure factors thus provides a relative means to compare potential risks among functional receptor groups.

<u>Wildlife TRVs and Benchmarks for Birds and Mammals</u>

USEPA has not yet developed standard toxicity benchmark concentrations or TRVs for terrestrial receptors. Therefore, TRVs from the literature will be used to derive LOAEL and NOAEL toxicity benchmarks for calculating risk to terrestrial wildlife. For some data reported in the literature, conversions of the TRVs to toxicity benchmarks are necessary to allow the TRVs for the laboratory test organisms (e.g., lettuce, rat) to be used for the Site receptors (e.g., plants, red fox). The terrestrial benchmarks to be used in the TERA will generally employ the TRVs published by ORNL (Sample et al. 1996). TRVs from other common literature sources will be used when ORNL values are not available. The TRVs for mammals and birds, and the literature sources for each, are shown in Tables 3-6 and 3-7, respectively.

TRVs are typically adjusted to wildlife toxicity benchmarks by applying one uncertainty factor from each of three categories: intertaxon extrapolation (f_i), toxicity test endpoint (f_t), and study duration (f_d), in accordance with USEPA Region 8 guidance in *Uncertainty Factor Protocol for Ecological Risk Assessment* (1997). These three categories of uncertainty factors are multiplicative:

$$\text{Total Uncertainty Factor} = f_i \times f_d \times f_t$$

The total uncertainty factor is used in the denominator to adjust the literature-based TRV to a wildlife toxicity benchmark:

$$\text{Wildlife Toxicity Benchmark} = \frac{\text{TRV}}{\text{Total Uncertainty Factor}}$$

Intertaxon uncertainty factors (f_i) will be used in this risk model to adjust TRVs to toxicity benchmarks for the wildlife functional group representatives. Table 3-8 presents the intertaxon uncertainty factors for mammals. These values are based on the values recommended by USEPA Region 8 (1997). Intertaxon uncertainty factors will not be used to calculate RBCs for avian receptors, as science does not currently support their use. In the absence of avian TRVs for some COPCs, mammalian TRVs will not be used for birds because extrapolation across classes of organisms is not recommended (USEPA Region 8 1997). The lack of avian TRVs for these COPCs is considered a data gap and will be addressed in the uncertainty evaluation in the ERA.

Uncertainty factors recommended by USEPA Region 8 for study duration (f_d) and toxicity test endpoint (f_t) will be used to adjust the wildlife TRVs to the wildlife chronic LOAEL and NOAEL benchmarks used as model input values (see Tables 3-6 and 3-7). These values are as follows:

Study Duration Extrapolation Factors (f_d):

Chronic	1
Subchronic to Chronic Exposure	3
Subacute to Chronic Exposure	5
Acute to Chronic Exposure	10

Test Endpoint Extrapolation Factor (f_t):

Nonlethal no observed effect	1
Lethal NOAEL to non-lethal NOAEL	3
Lethal LOAEL to non-lethal LOAEL	3
Non-lethal LOAEL to non-lethal NOAEL	3
Lethal LOAEL to non-lethal NOAEL	10
Frank effect (death) to non-lethal NOAEL	15

3.2.2 Radionuclides

The radionuclide results for surface material, sediment, and surface water will be screened against media-specific biota concentration guides (BCGs) from the current U.S. Department of Energy (USDOE) Biota Dose Assessment Committee (BDAC) *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (USDOE 2000). The USDOE graded approach includes three potentially applicable steps: (1) a general conservative screening where maximum exposure media concentrations are compared with BCGs, (2) a site-specific screening using average concentrations, and (3) a site-specific analysis.

In the Midnite Mine TERA, if the initial conservative screening against BCGs indicates no unacceptable risk in an exposure area (i.e., a mine-affected area), Steps 2 and 3 (listed above) are not required in any subsequent risk assessment since no risk is indicated in the conservative screening step. If the general conservative screening indicates a potentially unacceptable risk (sum of fractions is greater than 1.0 in an exposure area), a site-specific screening will be performed using average radionuclide concentrations. Also, a correction factor for the receptor residence time may be added, and consideration will be given to replacing the default parameter values with parameter values based on product of concentration ratios as suggested in USDOE (2000). A site-specific analysis (Step 3) is not anticipated since remediation activities due to risk from radionuclides would be more likely based on unacceptable cancer risk to exposed humans than risk to ecological receptors.

According to USDOE (2000), the overall absorbed dose from exposure to radiation or radioactive materials for terrestrial plants should not exceed 1 rad/day, and the absorbed dose for terrestrial and riparian animals should not exceed 0.1 rad/day. In a 1992 review of previous studies, the International Atomic Energy Agency (IAEA) concluded that appreciable effects to terrestrial plant and terrestrial animal populations were not expected at doses lower than the 1 rad/day and 0.1 rad/day dose, respectively (IAEA 1992).

BCGs have been derived for terrestrial plants and animals exposed to a range of radioactive isotopes in surface material/sediment (pCi/g) and surface water (pCi/L). Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium that would not result in recommended dose standards being exceeded (USDOE 2000). Therefore, overall exposure is the sum of exposures to surface material and surface water or sediment and surface water. In the TERA, exposure concentrations of site-related isotopes in surface material/sediment and surface water will be compared with the corresponding terrestrial plant and animal BCGs using a sum-of-fractions approach. The six site-related isotopes measured in surface material/sediment and surface water that have BCGs are: radium 226, radium 228, thorium 232, uranium 234, uranium 235, and uranium 238. BCGs for plants exposed to radionuclides in surface material and water are presented in Table 3-9. BCGs for terrestrial animals are presented in Table 3-10.

For the exposure media (surface material/sediment and surface water) and the site-related radionuclides (A, B, etc.) with concentrations (C_A, C_B, $C_{etc.}$), and corresponding terrestrial plant and animal BCGs, the sum-of-fractions process is as follows:

$$SUM = (C_A/BCG_A + C_B/BCG_B + C_n/BCG_n)_{\text{surface water}} + (C_A/BCG_A + C_B/BCG_B + C_n/BCG_n)_{\text{soil or sediment}}$$

If the sum of fractions is less than 1.0, it is concluded that the radionuclide dose to terrestrial plants and/or terrestrial animals in the exposure area does not exceed the recommended dose limit of 1 rad/day. Conversely, if the sum is greater than 1.0, the radionuclides at the location exceed the recommended dose.

Because sediment data are from two sample types (composite samples and grab samples), risk estimations for radionuclides in stream segments and water bodies will be presented for two combinations of data: (1) sediment composite sample plus surface water data and (2) sediment grab sample plus surface water data. For each stream segment/water body, radionuclide exposure concentrations for surface water and sediment will be used in the TERA. If a radionuclide was not detected in surface material/sediment or surface water, zero (0) will be substituted into the sum-of-fraction process as per guidance in USDOE (2000).

Unlike the COPC selection process for inorganics in surface material, sediment, and surface water (see Section 2.4.1 and 2.4.2), comparisons of MA and PIA radionuclides with background will be performed after the sum-of-fractions screening is completed for a given exposure area and the resulting sum exceeds 1.0, indicating potential risk (USDOE 2000). This is necessary because the sum of fractions incorporates the concentrations of six radionuclides. If the exposure area radionuclide sum-of-fractions is equal to or less than the comparative background sum, the exposure area has passed the radionuclide screening (i.e., the site is apparently not contributing radionuclides to the segment). Conversely, if the on-site radionuclide sum of fractions is greater than background, a portion of the radionuclide concentrations in the surface material/sediment and surface water in the particular exposure area may be due to mining effects in the MA or PIA.

As described above, site-specific screening (Step 2) would then be performed followed by comparison with background. Risk from radionuclides in background also would be recalculated using the same site-specific screening methods and assumptions applied to the Site. If the sum-of-fractions for an exposure area is greater than 1.0 based on site-specific screening and also exceeds background, the six radionuclides incorporated into the sum-of-fractions will be considered COCs for the exposure area.

4.0 RISK CHARACTERIZATION

In the Risk Characterization section, COPCs identified in Section 2.0 are carried through the risk estimation and risk description processes. COPCs that exceed background and criteria, guidelines, or RBCs are termed COCs.

4.1 Risk Estimation

Risk estimation is the process of comparing exposure concentrations and chemical effects data (USEPA 1998). Exposure concentrations described in Section 3.1.1 and chemical effects data (toxicity benchmark concentrations) described in Section 3.1.2 will be compared to determine risk in this section.

For terrestrial plants, soil organisms, earthworms, and amphibians an HQ will be calculated which is the ratio of the exposure concentration to the concentration not expected to result in an ecologically significant effect (i.e., toxicity benchmark) as follows:

$$\text{Hazard Quotient} = \frac{\text{Exposure Concentration}}{\text{Toxicity Benchmark}}$$

Potential risk for terrestrial plants, soil organisms, and earthworms will be evaluated by directly comparing soil exposure concentrations to soil concentration-based benchmarks published by Oak Ridge National Laboratory (ORNL) (Efroymson et al. 1997a,b). Evaluation of potential risk for amphibians will be evaluated by directly comparing surface water exposure concentrations to surface water concentration-based benchmarks published by USEPA (Schuytema and Nebeker 1996). For COPCs where the HQ > 1, that chemical will be considered a COC for the exposure area.

Potential risk for birds and mammals will be evaluated by comparing media-specific concentrations to RBCs developed as described in Section 3.2.1.3 to assess potential risk:

$$\text{Hazard Quotient} = \frac{\text{Exposure Concentration}}{\text{Risk-Based Concentration}}$$

If the HQ > 1.0 for a specific COPC, that COPC will be regarded as a COC for the receptor and exposure area.

See Section 3.2.2 for a description of risk analysis for radionuclides.

4.2 Risk Description

The quantitative risk estimation for surface material, sediment, and surface water data (Section 4.1) will provide the starting point for achieving the objective of the TERA, identifying COCs that present a potentially unacceptable risk to terrestrial biota or terrestrial habitats on the Midnite Mine Site.

The ecological significance of any exceedances of benchmarks and/or RBCs will be evaluated through discussions of measures of effects, exposure, and ecosystem/receptor characteristics as they relate to the assessment endpoints:

- Protection of the upland and riparian plant communities
- Protection of soil organism communities
- Protection of threatened and endangered wildlife species
- Protection of wildlife (functional groups) populations

The ecological significance of the potential risk will be evaluated for each sub-area in the context of the overall Midnite Mine Site and ecological conditions in surrounding areas. A major component of this discussion will be an evaluation of the effects of uncertainties associated with the assessment.

4.3 Uncertainties in the TERA

In conformance with USEPA (1997a) guidance, the TERA will include a full discussion of uncertainties that influence the interpretation of the results. The TERA will use conservative, yet reasonable, assumptions where the available site-specific data or toxicological information is incomplete. Multiple conservative assumptions and uncertainty factors generally result in conservative or over-protective risk estimates for ecological receptors. Some examples of various potential sources of uncertainty applicable to each major section of the TERA are described below together with estimates of the effect on the risk assessment.

Problem Formulation

- Development of the food web and CSM – Potential source of uncertainty due to limited knowledge about site-specific dietary composition, exposure pathways, and spatial and temporal constraints on exposure – *May overestimate or underestimate risk.*
- Uncertain occurrence of receptors at sites – The actual presence/abundance on-site of the Site receptor groups that are included in the food chain models is uncertain – *May overestimate risk.*

Exposure Analysis

- Uptake factor for prey items – An uptake factor typically derived using literature-derived equilibrium assumptions does not consider that only a finite mass of each chemical is available for the receptors (i.e., as in a fugacity model approach) – *May overestimate exposure and risk.*
- Bioavailability equal to one (1) – It is unlikely that 100 percent of a measured chemical is available for uptake – *Likely overestimates exposure and risk.*
- Exposure point concentration - It is unlikely any receptor would be exposed concurrently to maximum or 95th UCL concentrations of all chemicals in each area or in all media – *Likely overestimates exposure and risk.*

Ecological Effects of Chemicals

- Extrapolation of toxicological data from laboratory test species to wildlife receptor species – Species differ with respect to absorption, metabolism, distribution, and excretion of chemicals – *May overestimate or underestimate risk.*
- Suitability of USDOE (2000) BCGs for radionuclides – It is not known if USDOE's approach provides adequate protection for individuals of protected species – *May underestimate risk to individual organisms.*

Risk Characterization

- Background contaminant levels - Ecological risk at the Site is based on total concentrations of COCs. The portion of the total that is attributable to background levels is not factored out. – *May overestimate risk*.
- Risk evaluated for individuals – Effects on individuals may occur with little population- or community-level effect; however, as the number of affected individuals increases, the likelihood of population-level effects increases – *Likely overestimates risk to populations.*
- Presence of contaminants of interest (COIs) – Metals without toxicity benchmarks (COIs) add an unknown amount of risk – *May underestimate overall risk.*
- Multiple exposure media - For wildlife, separate RBCs are calculated for surface water and surface material/sediment; each is derived from an HQ of 1.0. Exposure to both media could lead to a combined HQ (index) greater than 1.0. – *May underestimate risk to wildlife at the Site.*

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